I. INTRODUCTION.

A. By Guy A. K. Marshall.

The observations and experiments which form the groundwork of the present memoir were originally undertaken by me at the instance of Prof. Poulton, and such interest as they may possess is largely due to his valuable suggestions and advice. Moreover he has been good enough to undertake the entire clerical work in connection with the publication of the paper, and he alone is responsible for the numerous excellent plates with which it is illustrated. The utility of experiments such as here recorded depends almost entirely upon the manner in which the results may be treated. The mere accumulation of facts of this kind has little real value, unless these facts are properly classified and co-ordinated, and their bearing upon current theories adequately considered and discussed. This portion of the work has been left almost entirely in Prof. Poulton's hands, and I feel that I am fortunate in having obtained his hearty co-operation; for his wide experience in this particular line of research insures a thorough treatment of the subject.

In carrying out the experiments I have always endeavoured, so far as in me lay, to record the results as impartially as possible. But on reviewing my experiences as a whole I cannot escape the conclusion that they lend very strong support to the theories of Mimicry and Warning Colours as enunciated by Bates, Fritz Müller, and Wallace; I feel convinced that were naturalists more ready to carry out extensive experiments of this nature there would be much less of the prevalent *a priori* criticism of these valuable theories which throw light upon a vast number of facts which must otherwise remain for us mere meaningless coincidences. It is especially important that experiments should be made by as many different observers as possible, for in this way alone can the errors due to unavoidable personal bias be eliminated; and if the present publication only has the effect of inducing other entomologists in South Africa, or elsewhere, to turn their attention to the interesting problems involved, it will have fully served its purpose.

G. A. K. M.

B. By E. B. Poulton.

The following memoir has been written upon and around the great mass of valuable material supplied by Mr. Guy A. K. Marshall's observations, experiments, and captures from 1896 to 1901. So far as this material consists of specimens it is open to the study and criticism of all naturalists; for it has been placed by the generosity of Mr. Marshall in the bionomic series of the Hope Department in the Oxford University Museum. The paper itself has been gradually growing during these years, not only by the accumulation of specimens, but by an uninterrupted correspondence between Mr. Marshall and myself. Extracts from Mr. Marshall's letters form a very important part of the whole work, and it is only right to point out that they were not written for publication, and that any want of co-ordination or continuity is entirely due to this cause. At the time when they were selected and arranged for publication there was no prospect of Mr. Marshall's return to England, and I was anxious that as many naturalists as possible might have the opportunity of reading the observations and discussions from which I had learnt so much and received such great pleasure; and when eventually he did return the paper had been read. Although no attempt was made to alter or re-write these extracts, Mr. Marshall's presence in England has made an immense difference in the work. We have been able to discuss the general arrangement and illustration as well as the details of many obscure and difficult subjects. On several points he has written paragraphs which give a far higher value to the paper. Where the experience of the naturalist on the spot has been specially required it has become available. The sections of the paper under my own name have also greatly benefited by his kind assistance, and the opportunity of discussing points of special difficulty or uncertainty. It will be clear to all who read the paper that Mr. Marshall and I do not entirely agree in the interpretation of many facts, especially those connected with the seasonal phases of *Precis*, and in the extent and predominance of Müllerian mimicry as compared with Batesian in Lepidoptera. For these and other reasons it is necessary to state explicitly that I am solely responsible

for the opinions and considerations set forth in the sections to the titles of which the initials "E. B. P." are appended (in both the contents and the text). Mr. Marshall's numerous and important contributions to these sections are always acknowledged and placed between inverted commas. The titles of Mr. Marshall's sections are indicated by the initials "G. A. K. M.," and my contributions to these are always placed between square brackets, and are furthermore indicated by my initials.

Colonel J. W. Yerbury has kindly contributed one section and Colonel C. T. Bingham another, and both have given much help in other parts of the work. Some of the most strange and interesting insects were undescribed species, and would have been comparatively valueless for the purpose of this memoir, were it not for the kind assistance of the naturalists who have written the Appendix. Dr. F. A. Dixey kindly read the proofs and made many valuable suggestions and corrections. Mr. C. J. Gahan has given much kind assistance in the sections dealing with Coleoptera and in the identification of species. The number of species sent by Mr. Marshall is so large that the work of identification has been very laborious and prolonged, and we desire warmly to thank Sir George Hampson and the whole of the staff of the Insect Department of the British Museum, every one of whom has been consulted at one time or another. We also wish to thank heartily Colonel C. T. Bingham, who has named the whole of the Hymenoptera; Colonel J. W. Yerbury, who has worked out the majority of the Diptera; Mr. M. Jacoby, who has named many Phytophaga; Monsieur Jules Bourgeois, who has named the *Lycidæ*, and Mr. W. L. Distant, who has named the Hemiptera. Much other kind assistance has been given and is acknowledged in the text of the work.

Valuable material with excellent data, comparing in a most interesting manner with that sent by Mr. Marshall, was contributed from British East Africa by my kind friends Mr. and Mrs. S. L. Hinde.

The thirteen uncoloured plates are reproduced from excellent negatives taken from the actual specimens by Mr. Alfred Robinson in the Oxford University Museum. The two coloured plates are reproduced from Mr. Horace Knight's drawings of the specimens.

A brief abstract of some of the chief results here recorded

in detail was communicated to the Zoological Section of the British Association at Bradford (Report 1900, pp. 793–4), and an abstract of the present paper is printed in the Proceedings of the meeting at which it was read (Proc. Ent. Soc. Lond., 1902, pp. x—xiii). Some of the observations were also brought before the International Zoological Congress at Berlin, 1901 (Verhandlung, p. 171). Lists of the specimens presented to the Hope Department and a brief statement of the principles which they illustrate have been published yearly in the "Report of the Hope Professor of Zoology" communicated to the "Oxford University Gazette." Allusion to some of the material and the problems it illustrates, has also been made by the present writer in Linn. Soc. Journ. Zool., vol. xxvi, 1898, p. 558, and Report Brit. Assoc., 1897, p. 689. Much has been written upon the work on seasonal dimorphism in the genus *Precis*, but full references will be found in this section of the present paper.

The first part of the following work, occupying just half of it, deals with experiments and observations upon insectivorous animals, and the conclusions and considerations arising out of this work. The experiments on *Mantidæ*, Kestrels, and baboons will be found to be especially numerous and important. A table shows all the examples of *Asilidæ* and the species forming their prey which could be found recorded or preserved in the British Museum and Hope Collection. The direct and indirect evidence of the attacks of birds on butterflies meets objections which are often raised, and indeed nearly the whole of this part of the paper is an effective reply to those who ask for facts rather than hypotheses. One very important side of the work is the employment of Coleoptera on a large scale, and the clear evidence of aposematic and synaposematic colours in the group. A comparison between the Coleoptera and Lepidoptera in this respect is attempted. The first half of the memoir ends with a section discussing and criticizing the conclusion that there is any great significance or value in human experience of the taste and smell of insects.

The second half of the work is more heterogeneous. Its first section attempts to supply an interpretation of the startling seasonal phases of butterflies of the genus *Precis*. In this section Dr. A. G. Butler's convenient

terms "wet phase" and "dry phase" * are generally used in preference to "form" or "variety," while Mr. Marshall's useful sign ⊕ to indicate the former and ⊙ to indicate the latter are freely employed. The remainder of the paper is chiefly devoted to the description of an immense mass of material illustrating mimicry and common warning colours in Rhopalocera, Coleoptera, Hymenoptera, and to a less extent Hemiptera. Many interesting conclusions emerge and are discussed.

I entirely agree with Mr. Marshall's opinion that an unbiassed consideration of the facts presented in this paper yields a very strong measure of support to the classical theories of Bates, Wallace and Fritz Müller. I would go further and maintain that Mr. Marshall's observations and experiments here recorded, place Africa in the first position as the region which supplies stronger evidence than any other of the validity of these theories. But I am even more impressed by the strong support yielded to the modern developments of Fritz Müller's theory of mimicry. Where has Professor Meldola's Müllerian explanation in 1882 of the common facies of specially-protected subfamilies of butterflies received such illustration as in the groups of synaposematic *Acræinæ* captured in one place and at one time; or the extension in 1887 by the present writer of the same interpretation to the types of insect colour and pattern which are common to a country, received such support as in the marvellous group of Mashonaland insects of many Orders with an appearance founded upon that of the distasteful Coleopterous genus, *Lycus?* And the most recent developments of all, the discovery (1894–7) of the principle of "reciprocal mimicry" or "diaposematic resemblance," and of the specially close mimetic resemblance of the females in Müllerian mimicry no less than in Batesian by Dr. Dixey, together with his Müllerian interpretation of resemblances between mimics overlying their resemblance to a common model, all these, founded on the study of Neotropical forms, have supplied the explanation of numerous instances in the Ethopian Region although applied to very different families and

* The term "phase" is advantageous inasmuch as it is conveniently applicable to the whole of the winter or summer generations of a species, as well as to single individuals of either seasonal form.

sub-families of butterflies, to Coleoptera as well as to Lepidoptera.

I cannot conclude without warmly thanking my friend Mr. Marshall for the pleasure I have enjoyed in the work which we have done together.

E. B. P.

2. Experiments on Mantidæ in Natal and Rhodesia. (G. A. K. M.) *Natal, February* 1897.

I. Gave a wingless *Acræa horta* to a Mantis. It seized it and threw it away. On a second presentation it felt the butterfly carefully with its antennæ, then took it and began eating first the haustellum, then the palpi, and finally the whole head with apparent relish. On biting at the thorax, however, it threw it down with evident disgust and began wiping its mouth on its fore-legs as though to take away the taste. I again presented the butterfly, but the Mantis at first only ran away from it. At last it took it again and began eating the thorax, but quickly threw it down and would have nothing more to do with it.

II. Experiment *a*.—Caught a full-grown Mantis and put it in a large green gauze bag. In the afternoon put in a house-fly, which was not eaten that day, but was gone next morning. Then put in a wingless male *A. horta* (a bitter yellow juice exuded from the wing stumps). On perceiving it the Mantis ran towards it, seized it and made a bite at the back of the thorax, but started back as if in great surprise, and wiped his mouth on his front legs. He exhibited both fear and curiosity; for as the *Acræa* approached he edged away, just keeping far enough off to be able to touch it with the end of his long antennæ, and when the *Acræa* walked away he followed, still feeling it over. At this point I was called away, and on my return found that the *Acræa* had been eaten all except the head and apical half of the abdomen. Afterwards put into the bag the *Amauris echeria* which had been rejected by spider C (Experiment 13), and which was half dead. As the Mantis took no notice of it I left, but on inspection in the evening I found that this butterfly had been entirely devoured, only a few small fragments of wings and legs being left.

Experiment *b*.—Gave the Mantis a perfect male *A.*